the cells, and their being moistened with good conducting liquids, insulation was destroyed, and no static effects at the terminal, or very feeble ones, were perceptible. This result, by far the most important of Mr. Gassiot's labours, was published in the *Phil. Trans.* of the Royal Society for 1844, p. 39. It got rid of the strongest objection to the chemical theory of the pile, and brought into harmony results which up to that time had appeared discordant.

In 1852 Mr. Grove had published in the *Phil. Trans.* of the Royal Society, in a paper "On the Electro-Chemical Polarity of Gases," an account of transverse dark bands or striæ, which he was the first to observe in the electric discharge. The discharges were obtained from a Ruhmkorf coil, and made to pass through attenuated gases, or what were commonly called *vacua*. Mr. Gassiot made a vast number of experiments on these striæ, the most important of which was that he obtained them in a Torricellian vacuum with the voltaic arc, showing that they did not depend on the intermittence of the discharge (occasioned by the contact-breaker), but accompanied all electric discharges *in vacuo*. There is, perhaps, some doubt whether the voltaic arc is absolutely continuous, or whether it does not produce, by its action on attenuated gas, something like waves (a stone thrown into water may be a rough simile), but at all events it is continuous in its inception, and in that respect quite different from the interrupted discharges of the contact-breaker apparatus, or the common electrical machine.

Mr. Gassiot devoted himself for a long time to procuring *vacua* as perfect as they could be obtained, for the examination of the electric or voltaic discharges, and proved distinctly that when the attenuation was pushed to a high degree of rarity, the electric discharge would not pass at all, a result which had been observed by Morgan (*Phil. Trans.*, vol. lxxv.), the accuracy of whose experiments was impugned by Davy.

Mr. Grove, as an answer to the contact theory of the voltaic pile, had shown that if two polished plates, one of zinc, the other of copper, were approximated, but kept from contact by a thin film of paper or mica, and then separated, the electric effects, alleged to be due to the contact of dissimilar metals, were produced; it was objected to this experiment, and not without reason, that these effects might be produced by friction of the paper or mica. Mr. Gassiot effectually got rid of this objection by bringing the plates into close proximity by a delicate micrometer apparatus and then quickly separating them; the same electrical results followed (*Phil. Mag.*, October, 1844).

The above are the principal of many curious results obtained by Mr. Gassiot. While thus giving up his leisure time to science, he was a diligent and successful man of business and a liberal promoter of, and contributor to, all useful scientific and benevolent objects, some of which we mentioned in our previous notice.

THE SPECTRUM OF NOVA CYGNI

In the *Monatsbericht* of the Royal Academy of Sciences of Berlin (May, 1877), Herr Vogel, the eminent astronomer, publishes the details of his investigations of the spectrum of the new star in Cygnus, and whilst expressing his own views with regard to the physical condition of the star, enters upon a criticism of those of other observers. Herr Vogel observed the spectrum on sixteen different nights; the first observation was made on December 5, when the star was of 4·5 magnitude; the last on March 10, when the magnitude was only 8·3.

Herr Vogel's observations show that the spectrum of the new star was a continuous one, showing numerous dark lines and bands and several bright lines. The intensity of this continuous spectrum, which at first was very brilliant, decreased rapidly, so that three months after the discovery of the star it was only partly visible, and even that part was very faint. The decrease of intensity did not spread evenly over the whole spectrum; the blue and violet rays grew fainter far more rapidly than the green and yellow rays. The red part of the spectrum, which already during the first observations was very dim and crossed by broad absorption bands, soon disappeared altogether, so that a bright line in the red seemed to remain quite isolated. At first a dark band in the green, and, later on, a very broad dark band in the blue, were particularly conspicuous. With the exception of a bright line in the red, the other bright lines at first surpassed the continuous spectrum but very little in brilliancy; they could therefore be seen only with difficulty. During the rather rapid decrease of intensity of the continuous spectrum they, however, became more easily discernible, and, as results from the measurements made, the hydrogen lines Hα and Hβ were particularly bright, and, later on, a line of 499 mill. mm. wave-length. This latter line remained longest when the spectrum faded away, and finally surpassed the hydrogen lines in intensity; the red hydrogen line was the first to grow fainter. The weather not having been very favourable, the measurements which Herr Vogel made have no claim to very great accuracy, but they at least prove that the following *bright* lines have appeared in the spectrum:—

1. The hydrogen lines $\left.\begin{matrix}H\alpha\\ H\beta\end{matrix}\right\}$ beyond doubt.
   Hγ most probably.
2. A line of 499 mill. mm. wave-length (± 1 mill. mm.). This line coincides tolerably well with the brightest line in the nitrogen spectrum under ordinary pressure; it is the same line which is brightest in the spectra of nebulæ.
3. An indistinct line of 580 m. mm. wave-length.
4. An indistinct line of 497 m. mm. wave-length. This nearly coincides with a close group of lines in the atmospheric spectrum.
5. Some bright lines were seen in the neighbourhood of *b* and *E*, but their position could not be measured. On December 5 two lines were measured in the blue (of 474 and 470 wave-lengths), and were also observed on December 8, but, later on, only the second one has again been seen as an indistinct band of 467 wave-length.

In the accompanying illustration (Fig. 2) we reproduce Herr Vogel's drawings, which supplement his observations, and, as he points out, contain many a detail which could not well be described in words.

Herr Vogel, in discussing the views of other astronomers, first deals with M. Cornu's observations. M. Cornu made his first observations on December 2 and 5 (see NATURE, vol. xv. p. 158); he succeeded in measuring several bright lines in the spectrum, viz., wave-lengths 661 (H α), 588, 531, 517, 500, 483 (H β), 451, 435 (H γ). He saw no dark bands distinctly in the continuous

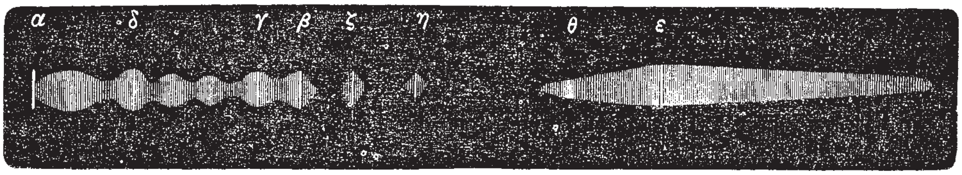
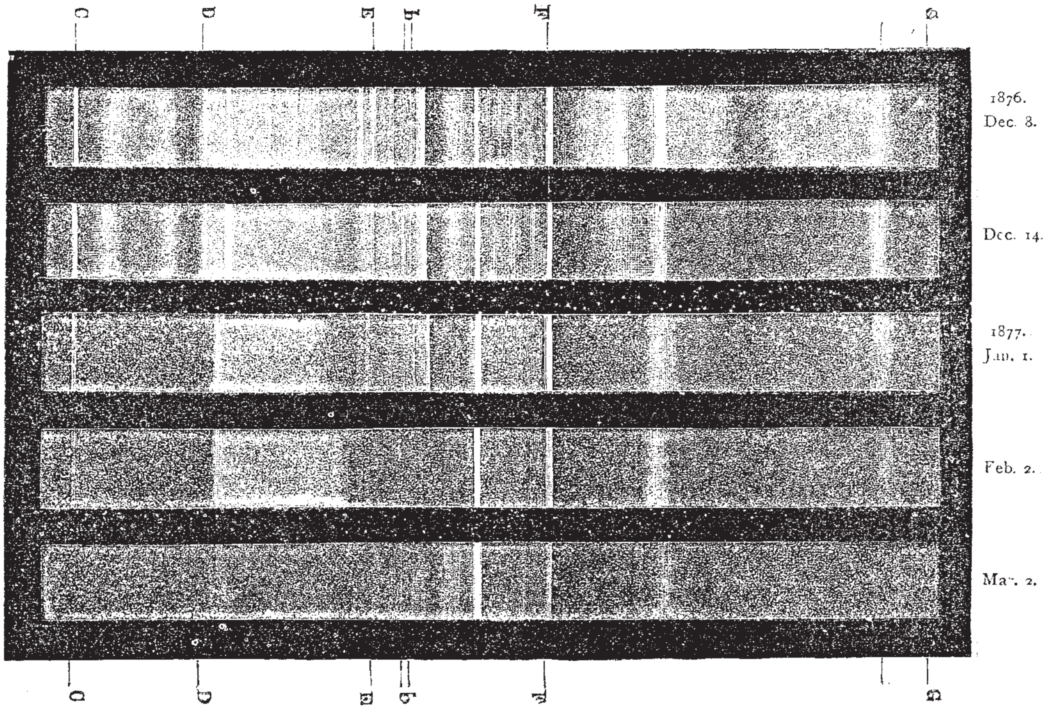


FIG. 1.—Cornu's Spectrum of Nova Cygni.

spectrum, "because," says Herr Vogel, "he doubtless observed with a spectroscope of too great a power of dispersion, and therefore many details escaped his notice. This supposition is confirmed by the drawing, published in the *Comptes Rendus* (t. 83, p. 1,172), where M. Cornu represents the spectrum as consisting of two parts, and, which contains no other details besides the bright lines.'

As the line 588 wave-length, measured in the star spectrum, corresponds closely with D_3, also the line 531 wave-length, with the well-known corona line (531,6 wave-lengths) and finally the line 517 wave-length, with the middle of the magnesium lines *b*, M. Cornu draws the conclusion that with regard to chemical composition the atmosphere of the star coincides completely with the chromosphere of our sun: "en résumé, la lumière de l'étoile parait posséder exactement la même composition que celle de l'enveloppe du soleil, nommée chromosphère." Herr Vogel, however, thinks that this conclusion is not altogether justified, since a line (500 wave-length), which does *not* occur in the chromosphere was distinctly visible with the other bright lines in the spectrum, and it eventually became the *brightest* line of the whole spectrum.' Comparing his own observations with those of M. Cornu, Herr Vogel points out that they agree perfectly with regard to the presence of the three hydrogen lines, and that of the brightest line of the atmospheric spectrum, or the principal line of the nebulæ spectrum (500 wave-length). He could not determine the position of the bright green lines with sufficient exactness; on one day he found for them 527 and 514 wave-lengths respectively, but these figures differ considerably from M. Cornu's; this is still more the case with the lines in the blue, for which he finds 466 wave-length, while M. Cornu has 451 wave-length. The line 588 wave-length of M. Cornu was observed by Herr Vogel on one occasion, but was not again seen afterwards.

Father Secchi, in a short note in the *Astronomische Nachrichten* (No. 2,116), says that M. Cornu's description of the spectrum of the new star is correct, with the exception that the bright lines were not indistinct but well defined, like lines in spectra of nebulæ. Father Secchi observed on January 7 and 8, when Herr Vogel also saw the lines well defined. He is very positive that one of the bright lines is a hydrogen line, another a magnesium line, and a third a sodium line; this, in Herr Vogel's opinion, is decidedly a mistake, because on January 8 the lines in the vicinity of the magnesium group were quite faint, and no bright line near *D* was to be seen. According to Herr Vogel, the bright lines which Father Secchi saw were a considerable distance away from the sodium and magnesium groups respectively, their wave-lengths being 500 and 580.



F G 2 —Vogel's Spectrum of Nova Cgyni.

Mr. Copeland, who worked with a star spectroscope of Herr Vogel's construction, which was connected with the 15-inch refractor of Lord Lindsay's observatory, made the first observation on January 2, when the star was of 7th magnitude. He found the spectrum to be remarkably bright and consisting of a faint, continuous spectrum, crossed by five bright lines, of which he determined the following wave-lengths:—(1) 655, intense bright red; (2) 581, middle of a rather bright band in the yellow, fading off rapidly on both sides; (3) 504, and (4) 486, bright, well-defined lines; (5) 456, faint line in the violet. Nos. 1 and 4 are the hydrogen lines; No. 3 is the brightest line of the nebulæ spectrum. On January 9, when the atmosphere was particularly favourable, Mr. Copeland observed two other lines, of 594 and 414 wave-lengths respectively. The first was a "very narrow line," the second "excessively faint, but still certainly and repeatedly seen." In the vicinity of about 525 wave-length, Mr. Copeland observed the maximum of intensity of the continuous spectrum. Mr. Copeland's observations agree very well with those of Herr Vogel; the only exception being the violet line (456) for which Herr Vogel found a greater wave-length. Line 414, observed by M. Copeland, may possibly have been the fourth hydrogen line Hδ, if 414 is not a mistake of the printer and should be 434, as it would be strange if Mr. Copeland had not seen the third hydrogen line H γ (434) which was distinctly visible. Mr. Copeland pointed out that the line of 580 wave-length corresponds closely with a line which Herr Vogel observed in the spectra of three faint stars, also belonging to Cygnus, which have quite abnormal spectra,

U 2

and Herr Vogel owns that, however small the similarity between these spectra and that of the new star may have been at first, a certain resemblance appeared when the latter grew fainter; not only the line in question coincided with one in these spectra, a coincidence was also evident in a maximum of brightness in the blue (467 wave-length) and in a dark broad band close to this maximum.

Mr. Backhouse, of Sunderland, observed the spectrum on January 26, and found the brightest line to be of 503 wave-length. He remarked in a note to NATURE (vol. xv. p. 295), that at the end of December, not this line but line F was brightest; Herr Vogel's observations quite agree with those of Mr. Backhouse.

In summing up and in his final remarks on this subject, Herr Vogel first of all declares that he cannot agree with M. Cornu's view as expressed by this observer in the following phrase:—"Malgré tout ce qu'il y aurait de séduisant et de grandiose à tirer de ce fait des inductions relatives à l'état physique de cette étoile nouvelle, à sa température, aux réactions chimiques dont elle peut être le siège, je m'abstiendra de tout commentaire et de toute hypothèse à ce sujet. Je crois que nous manquons des données necessaires pour arriver à une conclusion utile, ou tout au moins susceptible de controle; quelque attrayantes que soient ces hypothèses, il ne faut pas oublier qu'elles sont en dehors de la science, et que loin de la servir, elles risquent fort de l'entraver."

Herr Vogel thinks that the fear that a hypothesis might do harm to science is only justifiable in very rare cases; in most cases it will further science, in the first place because it draws the attention of the observer upon things, which, without the hypothesis, he might have neglected. Of course, if the observer is so strongly influenced, that in favour of a hypothesis he sees things which do not exist—and this may happen sometimes—science may for a while be arrested in its progress, but in that case the observer is far more to blame than the author of the hypothesis. On the other hand it is very possible that an observer may—involuntarily—arrest the progress of science, even without originating a hypothesis, by pronouncing and publishing sentences which have a tendency to diminish the general interest in a question, and which do not place its high significance in the proper light. Herr Vogel is almost inclined to think that such an effect might result from the reading of the above phrase by M. Cornu, and is of opinion that nowhere better than in the present case, where in short periods colossal changes showed themselves occurring upon a heavenly body, the necessary data might be obtained for drawing useful conclusions, and the test of those hypotheses which have been ventured with regard to the physical condition of heavenly bodies, might be made.

A stellar spectrum with *bright* lines is always a highly interesting phenomenon for any one acquainted with stellar spectrum-analysis, and is well worthy of deep consideration. Although in the chromosphere of our sun, near the limb, we see numerous bright lines, yet only dark lines appear in the spectrum whenever we produce a small star-like image of the sun and examine it through the spectroscope. It is generally believed that the bright lines in some few star-spectra result from gases which break forth from the interior of the luminous body, and the temperature of which is higher than that of the surface of the body, *i.e.*, the same phenomenon we observe sometimes in the spectra of solar spots, where incandescent hydrogen, rushing out of the hot interior, becomes visible above the colder spots through the hydrogen lines turning bright. But this is not the *only* explanation. We may also suppose that the atmosphere of a star, consisting of incandescent gases, as is the case in our sun, is on the whole colder than the nucleus, but with regard to the latter is extremely large. Herr Vogel cannot well imagine how the phenomenon can last for any long period if the first hypothesis be correct. The gas breaking forth from the hot interior of the body will impart a portion of its heat to the surface of the body and thus raise the temperature of the latter; consequently the difference of temperature between the incandescent gas and the surface of the body will soon be insufficient to produce bright lines, and these will disappear from the spectrum. This view applies perfectly to stars which suddenly appear and soon disappear again, or at least decrease considerably in intensity, *i.e.*, for so-called *new* stars, in the spectra of which *bright* lines are apparent, if the hypothesis mentioned below is admitted for their explanation. For a more stable state of things the second hypothesis seems to Herr Vogel to be far more adapted; he thinks, therefore, that stars like β Lyræ, γ Cassiopeiæ, and others, which show the hydrogen lines and line D_3 *bright* on a continuous spectrum, with only small oscillations of intensity, possess very large atmospheres in proportion, consisting of hydrogen and the unknown element which produces the line D_3. With regard to the new star Herr Vogel points to a hypothesis which Herr Zoellner deduced from Tycho's observations of the star named after him, long before the considerable progress had been made in stellar physics by means of spectrum analysis. Zoellner supposes that upon the surface of a star, through the constant exhalation of heat, the products of cooling, which in the case of our sun we call sun-spots, accumulate in such a way that finally the whole surface of the body is covered with a colder stratum which gives much less light or none at all. Through a sudden and violent tearing up of this stratum the interior incandescent materials, which it incloses, must naturally break forth, and must, in consequence, according to the extent of their eruption, cause larger or smaller patches of the dark envelope of the body to become luminous again. To a distant observer such an eruption from the hot and still incandescent interior of a heavenly body must appear as the sudden flashing up of a *new* star. That this evolution of light may under certain conditions be an extremely powerful one, could be explained by the circumstance that all the chemical compounds which under the influence of a lower temperature had already formed upon the surface, are again decomposed through the sudden eruption of these hot materials, and that this decomposition, as in the case of terrestrial substances, takes place under evolution of light and heat. Thus the bright flashing up is not only ascribed to the parts of the surface which through the eruption of the incandescent matter have again become luminous, but also to a simultaneous *process of combustion*, which is initiated through the colder compounds coming into contact with the incandescent matter.

Zoellner's hypothesis on the gradual development of heavenly bodies, as he states it in his "Photometric Researches" (p. 231, &c.), has been confirmed *in its essential points* by the application of spectrum-analysis to the stars. We recognise the different states of cooling in the spectrum, and in the cases of some fainter stars we have distinct data that in the atmospheres surrounding incandescent bodies, chemical compounds may already form and continue to exist. The hypothesis on *new* stars is in no wise contradicted by the spectral observations made of the two new stars of 1866 and 1876. The very bright continuous spectrum and the bright lines, which at the beginning only slightly exceeded its brilliancy, could not be well explained if we only suppose a violent eruption from the interior, which again rendered the surface (or part of it) luminous, but are easily explained by the hypothesis that the quantity of light is considerably augmented through a simultaneous process of combustion. If this process is of short duration, then the continuous spectrum, as was the case with the new star of 1876, will very quickly decrease in intensity down to a certain limit, while the bright lines in the spectrum, which result from the incandescent gases that have emanated in enormous quantities from the interior, will remain for some time.

The observations of the spectrum show beyond doubt that the decrease in the light of the star is in connection with the cooling of its surface. The violet and blue parts decreased more rapidly in intensity than the other parts, and the absorption bands, which crossed the spectrum, have gradually become darker and broader.

Finally Herr Vogel regrets that the news of the discovery of the new star by Herr Schmidt was only known so late, as doubtless during the first few days most interesting changes must have occurred in the spectrum, while the star rapidly decreased in brightness. Herr Vogel recommends that in case of appearance of other new stars no time should be lost before spectral observations are made, and points out that even with small telescopes very useful results may be obtained, if care is taken that spectroscopes are used of sufficiently low power of dispersion.

The position of the new star with regard to two neighbouring stars of magnitudes 9·1 and 9·4 Herr Vogel has determined as follows :—

Nova – ∗ $9^m{\cdot}1$ (*Bonn. Durchmust* , + 42°, 4184)
1877·0 $\Delta\alpha = -25^s{\cdot}00$ $\Delta\delta = +1'\,15''{\cdot}4$
Nova – ∗ $9^m{\cdot}4$ (*Bonn. Durchmust.*, + 42°, 4185)
1877·0 $\Delta\alpha = -35^s{\cdot}34$ $\Delta\delta = -1'\,13''{\cdot}2$.

As the first of the comparison stars has been determined at the meridian circle of Bonn, the position of the new star is :—

1877·0, 21h. 36m. $52^s{\cdot}48$ + 42° 16′ $54''{\cdot}5$.

THE TELEPHONE[1]

In the following paper I call instruments employed in the transmission of musical sounds, tone telephones, and those employed in the transmission of the human voice, articulating telephones.

In the year 1837, Page, an American physicist, discovered that the rapid magnetisation and demagnetisation of iron bars produced what he called "galvanic music." Musical notes depend upon the number of vibrations imparted to the air per second. If these exceed sixteen we obtain distinct notes. Hence, if the currents passing through an electro-magnet be made and broken more than sixteen times per second, we obtain "galvanic music" by the vibrations which the iron bar imparts to the air. The iron bar itself imparts these vibrations by its change of form each time it is magnetised or demagnetised.

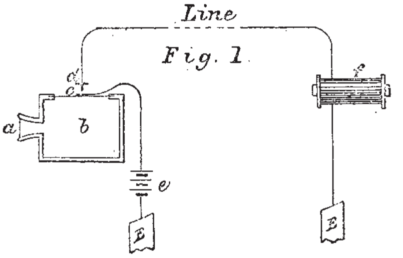


Fig. 1.

De la Rive, of Geneva, in 1843, increased these musical effects by operating on long stretched wires which passed through open bobbins of insulated wire.

Philip Reiss, of Friedrichsdorf, in 1861, produced the first telephone which reproduced musical sounds at a distance. He utilised the discovery of Page by causing a vibrating diaphragm to rapidly make and break a galvanic circuit. The principle of his apparatus is shown Fig. 1.

b is a hollow wooden box into which the operator sings through the mouthpiece *a*. The sound of his voice throws the diaphragm *c* into rapid vibration so as to make and break contact at the platinum points *d* at each vibration. This interrupts the current flowing from the batteries *e* as often as the diaphragm vibrates, and therefore magnetises and demagnetises the electro-magnet as often. Hence whatever note be sounded into the box *a* the diaphragm *c* will vibrate to that note, and the electro-magnet *f* will similarly respond and therefore repeat that note.

Musical sounds vary in tone, in intensity, and in quality. The tone depends on the number of vibrations per second only; the intensity on the amplitude or extent of those vibrations; the quality on the form of the waves made by the vibrating particles of air.

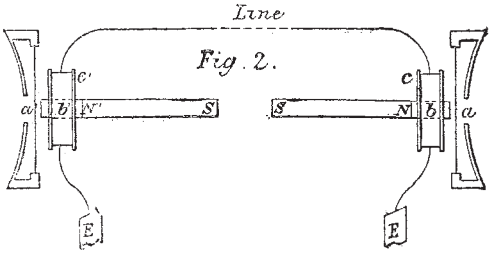


Fig. 2.

It is evident that in Reiss's telephone everything at the receiving end remains the same, excepting the number of vibrations, and therefore the sounds emitted by it varied only in tone and were therefore notes and nothing more. The instrument remained a pretty philosophical toy and was of no practical value.

Cromwell Varley, in 1870, showed how sounds could be produced by rapidly charging and discharging a condenser.

After alluding to the invention of Mr. Elisha Gray (NATURE, vol xiv. p. 30), Mr. Preece said :—

It remained for Prof. Graham Bell, of Boston, who has been working at this question with the true spirit of a philosopher since 1872, to make the discovery by which tone, intensity, and quality of sounds can all be sent. He has rendered it possible to reproduce the human voice with all its modulations at distant points. I have spoken with a person at various distances up to thirty-two miles; and through about a quarter of a mile I have heard Prof. Bell breathe, laugh, sneeze, cough, and in fact make any sound the human voice can produce. Without explaining the various stages through which his apparatus has passed, it will be sufficient to explain it in its present form. Like Reiss he throws a diaphragm into vibration, but Prof. Bell's diaphragm is a disc of thin iron *a*, which vibrates in front of a soft iron core *b*, attached to the pole of a permanent bar magnet N S (Fig. 2). This core becomes magnetised by the influence of the bar magnet N S, inducing all around it a magnetic field, and attracting the iron diaphragm towards it. Around this core is wound a small coil *c* of No. 38 silk-covered copper wire. One end of this wire is attached to the line wire, the other is connected to the earth. The apparatus at each end is identically similar, so that it becomes alternately transmitter and receiver, first being put to the mouth to receive sounds, and then to the ear to impart them. Now the operation of this apparatus depends upon the simple fact that any motion of the diaphragm *a* alters the condition of the magnet field surrounding the core *b*, and any alteration of the magnet field, that is either its strengthening or weakening, means the induction of a current of electricity in the coil *c*. Moreover, the strength of this induced current depends upon the amplitude of the vibration, and its form or the rate of vibration. The number of currents sent of course depends upon the number of vibrations of the diaphragm. Now each current induced in the coil *c* passes through the line wire to the coil c^1, and then it alters the magnetisation of the core b^1, increasing or diminishing its attraction for the iron diaphragm a^1. Hence the diaphragm a^1 is vibrated also, and every vibration of the diaphragm *a* must be

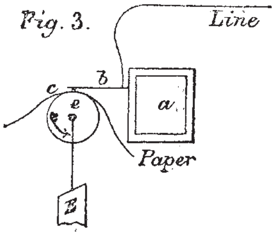


Fig. 3.

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[1] Paper read by Mr. W. H. Preece, Memb. Inst. C.E., at the Plymouth Meeting of the British Association. For the sectional cuts we are indebted to *Engineering*.